Technology as a Means to Bridging the Literacy Gap between Children with Normal Hearing and Children with Severe to Profound Hearing Loss

Capstone Project

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By

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Abstract

The language and reading development gap that exists between children with normal hearing and children with severe to profound hearing loss has been well documented and supported with past research (Ching et al., 2010). With the advent of the Universal Newborn Hearing Screening program, children with severe to profound hearing loss are diagnosed earlier, and more importantly, receive intervention for their hearing loss earlier (Marcoux & Hansen, 2003). Improvements in hearing aid technology and cochlear implants have the potential for providing children with severe to profound hearing loss an increased amount of auditory information vital for language and reading development. Although cochlear implants have helped to somewhat close the literacy gap between children with normal hearing and children with severe to profound hearing loss, a gap still presently exists. This paper provides an overview of language and reading development for children with severe to profound hearing loss, and aims to determine best practices regarding present technology for children with hearing loss.

Dedication

I dedicate this paper to my parents, Jim and Jane Minton, and my husband, Andrew, who have always been extremely supportive of my education.

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CHAPTER 1

Introduction

Research has documented the delay of language development in children with severe to profound hearing loss (Ching et al., 2010). This delay in language development often causes children with hearing loss to fall behind their peers with normal hearing in the area of literacy (Connor & Zwolan, 2004). Fortunately, there have been many advances in technology that have attempted to bridge the reading development gap for children with hearing loss. Improvements in hearing aids, FM systems, and the advent of cochlear implants have created new possibilities for children with hearing loss. With these advances in technology and with the age of identification of hearing loss decreasing due to early detection and intervention (EHDI) programs in the United States (Joint Committie on Infant Hearing, 2000), decisions about intervention are made earlier in a child's life. The Joint Committee on Infant Hearing (JCIH) guidelines state that a child identified with hearing loss should receive intervention by the age of six months (JCIH, 2000). Intervention for severe to profound hearing loss may include but is not limited to: hearing aids at a young age, early implantation of a cochlear implant, learning a sign system, or aural rehabilitation (Calderon, Bargones, & Sidman, 1998). For a parent with a child who is deaf, they look to the expertise of their child's audiologist. Therefore, it is important that audiologists base clinical recommendations and decisions on evidence in the research and previous clinical cases. The purpose of this paper is to review the existing research on language and literacy development in children with severe to profound hearing loss. In addition to the research regarding difficulty in reading development for children with hearing loss, options in technology for early intervention will be reviewed. Lastly, this paper will aim to answer the question: are cochlear implants the best practice for children with severe to profound hearing loss regarding language and literacy development?

CHAPTER 2

Language Development

Language development in children with normal hearing

In order to understand the language development of children who are deaf, it is important to explore typical language development in children with normal hearing. Exploring the process of language development will guide the discussion of literacy development in children which is the ultimate goal. There are five main aspects of language: phonology, morphology, semantics, pragmatics, and syntax. Phonology is described as the sound structure of speech. Knowledge of phonology, otherwise known as phonemic awareness, is considered the building blocks for language development. These building blocks of language lead to literacy because pairing a phoneme to a grapheme is the process of reading (Trezek, Wang, and Paul, 2010b). Phonological awareness starts with an ability to distinguish sound-based difference between words. It later evolves into the skill of manipulating sounds to form new words. Children with normal hearing who struggle with phonemic awareness are often poor readers (DesJardin, Ambrose, & Eisenberg, 2009; Sutcliffe, Dowker, & Campbell, 1999). Phonological awareness includes rhyming, syllable and word awareness, and alliteration (DesJardin et al., 2009). Research has shown that children develop syllable and rhyme awareness around the age of 3 and 4 years, and soon after develop their phonological awareness skills (Carroll, Snowling, Hulme, & Stevenson, 2003). Phonology and phonemic awareness provide children with the sound structure of speech and with a solid foundation of phonological skills; children have a base to build their language.

Morphology is related to phonology, and is also important for the development of literacy. Morphology refers to the meaning of words in relation to their structure. This aspect of language involves being able to break words apart into their smallest unit of meaning (Gaustad, Kelly, Payne, & Lylak, 2002). Morphologic knowledge begins by an emerging reader recognizing a word in print. Through repeated recognition in text, the word becomes automatic for the reader. An individual with normal hearing builds morphologic knowledge through analyzing words and from contextual situations (Gaustad et al., 2002). Morphology provides children with the structure of language, and along with the other aspects of language, a foundation for literacy is built.

Semantics is the area of language that deals with word meaning and vocabulary development (Samsonovic & Ascoli, 2010). Childers and Tomasello (2002) reported that 1-year old children receptively learn around one new word a day and 2-year old children receptively learn around two new words per day, and are months later able to express these new words. Hoff and Naigles (2002) reported that children's vocabulary develops from experience and exposure to language. They also explained that the more words a child hears, the higher the likelihood the child will learn more words (Hoff & Naigles, 2002). Although children hear hundreds of new words each day, they only learn about two of them (Childers & Tomasello, 2002). Fenson, Reznick, Thal and Pethick (1994) reported that typically developing children have a mean of 55 expressive words at 16 months old, and 225 expressive words at 23 months old. Word meaning is obviously an essential part of language, and continues to develop on a daily basis.

Syntax is the aspect of language that encompasses grammar, or the organization of words in a sentence. The structure and organization of a sentence can play a major role in the meaning of language which makes syntax an important part of language development. It has been shown that care-givers' interactions with infants happen in an organized, sequential manner, which helps to later develop the acquisition of syntactical order (Jung & Short, 2004). Pragmatics refers to the set of rules that is needed to communicate appropriately, such as sticking with one topic and turn taking in a conversation. The context of language is defined by pragmatics. Children with normal hearing are exposed to many conversations in their natural environments where they acquire pragmatic skills necessary for communication, often by incidental learning (Most, Shina-August, & Meilijson, 2010). Pragmatics and syntax are both improved with continued social interactions and are necessary for the full development of language.

While all the aspects of language are important for a child's language development, knowledge and development of a spoken language is critical. Jung and Short (2004) reported that infants with normal hearing typically develop syllabic babbling around 7 to 10-months of age. Around 12 to 14-months of age, sequences of meaningless babble, which sound like sentences, emerge in children with normal hearing. Developing the aspects of language and knowledge of a spoken language, however, is much different for children with severe to profound hearing loss.

Defining deafness

There are many interpretations of the word “deaf.” The American Speech-Language-Hearing Association (ASHA) defines deafness as a hearing disorder that restricts an individual’s communication causing the individual to use an alternate sensory system other than the auditory system for the purpose of communication. In addition, a hearing disorder may hinder the development, understanding and production of language and/or speech (ASHA, 1993). Trezek, Wang and Paul (2010a) define deaf using more of an audiometric classification, in which anyone with severe to profound hearing loss is considered deaf. Trezek et al. adds the caveat that the degree of hearing loss can affect one person very differently than it affects another person with the same degree of loss. For the purpose of this paper, deaf is defined as hearing loss that is severe to profound in degree.

Language development in children who are deaf

Children who are deaf are at a major disadvantage when developing language due to the fact that they have limited access to auditory information. Every aspect of language is affected in some way due to the restricted amount of auditory input. Phonological awareness, which begins as recognition of differences and similarities between sounds, can be very difficult for a child who is deaf. The information about phonemes that can be acquired through sound is often impossible to distinguish through other means such as lipreading (Sutcliffe, Dowker, & Campbell, 1999). Harris and Beech (1998) found that children with severe to profound pre-lingual deafness did significantly poorer on tests specific to phonological awareness when compared to their peers with normal hearing. A study by Sterne and Goswami (2000) explored whether deaf children had phonemic awareness at three different levels including: syllable, rhyme, and phoneme. They found that at the level of the syllable, the deaf subjects had equivalent awareness to that of the chronological age controls. They also found that the deaf subjects' rhyme awareness and awareness at the phoneme level was poorer than that of the younger hearing control group (Sterne & Goswami, 2000). Other studies have reported that the sequence of developing phonological awareness is similar and typical in children with normal hearing and children who are deaf, but is acquired at a slower rate for the children who are deaf (Johnson & Goswami, 2010). Phonology, which is an important aspect of language, is greatly affected by deafness.

There has not been much research in the area of development of morphology in children who are deaf. One study by Gaustad, Kelly, Payne and Lylak (2002) explained that children who are deaf have insufficient opportunities to discover meaning and form of the English language. In a study of deaf middle school and college students, Gaustad et al. found that those students had severe deficits in morphological knowledge when compared to their hearing peers. Van Hoogmoed, Verhoeven, Schreuder and Knoors (2011) postulated that words which are infrequent and not automatically recognized by the reader require morphologic processing. They found that morphological processing is used more by hearing children than deaf children for the purpose of word recognition. A child who is deaf is once again at a disadvantage when developing language because of a deficiency in morphological development.

Semantics is also an area of language that is negatively impacted by hearing loss. Vocabulary size, speed of word acquisition, and the ability to develop word-learning skills are significantly hindered by hearing loss (Prezbindowski & Lederberg, 2003). Trezek, Wang and Paul (2010c) reported that most children who are deaf possess smaller vocabularies than their peers who have normal hearing, even with assistive technologies. Yoshinaga-Itano, Sedey, Coulter and Mehl (1998) compared a group of children identified with hearing loss before the age of six months (early identified) and a group of children identified after six months of age (later identified). They found that the early identified group, with proper intervention, had significantly better expressive and receptive vocabularies than the later identified group when matched for cognitive ability, age at the time of the study, mode of communication, gender, degree of hearing loss, and other factors. Calderon, Bargones and Sidman (1998) reported that children that began receiving intervention around 21 months of age were an average of eleven months behind for expressive vocabulary and eight months behind for receptive vocabulary when exiting intervention. In general, children with severe to profound hearing loss have decreased vocabularies, slower acquisition of new words, and are behind in both receptive and expressive vocabulary development.

Syntax, which was described earlier as the grammar of language, develops in infancy when the child is still pre-verbal. During social interactions with a care-taker, the child enhances their knowledge of structure and sequence, which may be negatively affected by lack of linguistic input due to hearing loss (Jung & Short, 2004). Pragmatics is an area of language that is often influenced by hearing loss. Most et al. (2010) found that children with hearing loss could display mostly correct pragmatic abilities, but had not mastered the abilities as their age-matched peers with normal hearing had. They also found one area of pragmatics that the children with hearing loss were significantly behind in was contingency: continuing with one topic while adding additional information to the conversation. Lederberg and Everhart (2000) also found that children with hearing loss were less able to maintain the topic of conversation and used fewer questions than the children with normal hearing. Syntax and pragmatic also seem to be negatively affected by hearing loss, especially maintaining one topic of conversation.

With all the aspects of language affected by hearing loss, it makes developing literacy difficult. It has been reported that the average student who is deaf graduates high school with a similar reading level to that of a fifth grade normally hearing child (Holt, 1994; Yoshinaga-Itano et al., 1998). In the following chapter, literacy development of children who are deaf is explored further.

CHAPTER 3

Reading Development

The stages of reading development

The development of literacy happens in stages, and is dependent on a concrete knowledge of the language skills that were discussed earlier (Kamhi & Catts, 2002). In 1976, Chall outlined the five proposed stages of reading development for children with normal hearing. The first stage, which is labeled the decoding or initial stage, happens between the age of 6 and 7 years. In this stage, children further develop their already existing knowledge of phonological awareness, with the letter/sound relationship. In addition, children in this stage are using their own knowledge of the world to fill in the blanks of their syntax and semantic skills. In the next stage, the confirmation and fluency stage, children are around seven to eight years of age. At this stage, children do not need to decode every word they come across, and they become more fluent in their reading. In the confirmation stage, children are mostly reading information that is familiar to them, and are not reading to learn new information. Chall (1976) described that literacy can come to a standstill at stage two for adult learners or children with limited access to reading materials. In the first two stages of literacy development, children begin decoding words, and progressively build upon their fluency.

It is in the third stage, which happens between ages 8 and 14-years, children start using their literacy skills to read for new knowledge. In stage one, two, and the beginning of three, learning by listening and watching is more efficient than reading. As children progress through stage three, reading becomes an equal method of learning to listening and watching. In stage three children use both top-down and bottom-up processing, but are still mostly reading for one viewpoint only. Chall (1976) also explained that children must bring prior knowledge to their reading experience in order to gain new knowledge from the print. During the high school years, children enter the fourth stage of reading, multiple viewpoints. Stage four is mostly attained by formal schooling and building upon facts previously learned. The final stage, stage five, is usually acquired by the age of eighteen years. The fifth stage is the world view, and individuals in this stage can selectively read material with a more qualitative approach (Chall, 1976; Spencer, Barker, & Tomblin, 2003). The stages of reading are complex, and a delay in any one stage can cause delayed reading abilities.

Factors that affect development of literacy

There are many factors that can affect the development of literacy. Some of these factors include: parents' education level and occupation, family income and socioeconomic status, home literacy environment, and cognitive ability of the child (Schiff & Lotem, 2010; Noble & Mccandliss, 2005). For the purpose of this paper, hearing loss will be the main factor discussed. Bishop and Adams (1990) reported that children with delayed language milestones are at risk for delayed reading development. Harris and Beech (1998) explained that it is well established that children with severe to profound hearing loss have difficulty with reading development, but the underlying reason for this is debated. Proposed factors that influence literacy are: phonological awareness, language proficiency, print-related knowledge, and nonverbal abilities. These factors are mostly dependent on children's ability to hear spoken language (Harris &

Beech, 1998; Martindale, 2007). Kyle and Harris (2010) also reported that a large body of evidence shows that children with severe to profound hearing loss are significantly delayed in their reading abilities. Harris and Beech (1998) found that after three months of reading instruction, a group of children with normal hearing were able to read twice as many words as the group of children who were deaf. They also found that the group of children with normal hearing scored almost 20 percent better on phonological tasks than their peers who were deaf. For both the hearing and the deaf groups, there was a positive correlation between their score on the phonological tasks and reading development one year later (Harris & Beech, 1998). This study among others illustrates the affect that hearing loss has on literacy development, and how a deficit in language development can largely affect the development of reading in children.

Kyle and Harris (2010) carried out a longitudinal study that included 29 children with severe and profound hearing impairment. They found that speechreading and early vocabulary development were strong predictors of later reading development and literacy growth. Speechreading is the method of using the visual pathway to assign meaning to speech (Markides, 1979). Early vocabulary development was especially telling of later comprehension skills in reading. They reported that earlier findings had shown that vocabulary knowledge and phonological awareness were correlated to reading comprehension. Based on their findings, Kyle and Harris concluded that hearing children and deaf children go through the same process for reading development, but with one significant difference. They stated that deaf children may use speechreading skills in the way that hearing children use phonological awareness to develop coding for reading

(Kyle & Harris, 2010). The idea that deaf children learn reading in a manner similar to children with normal hearing only at a different rate, has been coined the qualitative similarity hypothesis.

Qualitative similarity hypothesis

Before the qualitative similarity hypothesis can be discussed, the Matthew Effect must be defined. A critical period for developing reading skills is the basis of the Matthew Effect. The critical period states that children need to gain the basic reading fundamentals by a certain age, which is usually around the end of third grade. After the third grade, reading difficulty increases due to more dense literature, making it hard to catch up for children that are behind (Paul & Lee, 2010). The Matthew Effect stems from the idea that “the rich get richer” or the “poor become poorer”, or in other words, good readers flourish and become better readers, and poor readers do not improve in their reading abilities. Vocabulary development and reading possess a reciprocal relationship that requires the reader to constantly have growth in their development of vocabulary in order to enhance reading development. Children that are strong readers tend to read more words, enjoy reading more, and learn the meaning of more words. This causes a growth in reading development for these strong readers, which allows them to acquire knowledge and skills at a faster rate compared to children who are poor readers. When children are poor readers, they are unable to read enough to strengthen vocabulary skills, are slower at reading, read less words, which therefore makes it difficult to improve literacy skills. Once the critical period for language and reading development passes, it is nearly impossible for these individuals to reach appropriate literacy levels (Stanovich, 1986;

Paul & Lee, 2010). There has been a dispute between professionals in the area of language on this point. On one side are the professionals that believe children will catch up to their peers in the end, and the other side which argue the development is similar, but will never reach the level of reading that normal hearing peers reach (Paul & Lee, 2010). Paul and Lee (2010) indicated that Stanovich's interpretation of the Matthew effect has lead to the research that helped to develop the qualitative similarity hypothesis.

The qualitative similarity hypothesis can be applied to children that are learning English as their first language, or children that are deaf and learning English as a second language. The hypothesis says that children who are deaf go through the same process of learning to read as children with normal hearing, but at a slower rate. This process includes comparable stages of learning to read, similar strategies and errors are made that posses the same qualities between children who are deaf and children with normal hearing. The qualitative similarity hypothesis also states that children who are deaf will ultimately reach the same development of reading as children with normal hearing, albeit at an older age in childhood. These principles of the qualitative similarity hypothesis suggest that all individuals, whether hearing or deaf, need a degree of competence in certain aspects of language in order to obtain proficiency in literacy (Paul & Lee, 2010). The qualitative similarity hypothesis states that stages of reading development are similar for children who are hearing and who are deaf, but occur at a slower process.

There have been studies to provide evidence of the qualitative similarity hypothesis, but further research needs to be completed. The first example of evidence of qualitative similarity hypothesis is shown in a national sample of deaf students analyzed by Paul and Lee (2010). This sample indicated that the average 8-year old student with normal hearing received a higher score on syntax tasks than the average 18-year old student who was deaf. Regardless of the delay in these skills, it was illustrated that the deaf children went through the same process, produced similar errors, and used similar strategies as the younger hearing children. Paul and Lee (2010) also reported that previous studies have shown similarities in development of vocabulary, comprehension, and syntax between children who are deaf and children with normal hearing. Even though there is evidence showing the qualitative similarity hypothesis exists, there will always be exceptions among certain individuals.

CHAPTER FOUR

Bridging the Gap

As discussed in the first three chapters of this review, there is a considerable gap in the development of language and reading in children who are deaf and children with normal hearing. This gap usually expands over time, and as children who are deaf move through school they experience more difficulty with academics (Harris & Terleksi, 2010). Luckily, with the improvements of early intervention for hearing loss, children with severe to profound hearing loss can receive technology that increases their access to sound. The expectation is that children who have an increased access to sound have a better chance to succeed in language and reading, because it provides another avenue to the development of phonological awareness in addition to speech reading (Harris & Terleksi, 2010). As mentioned earlier, phonological awareness is a major contributor to the development of literacy. Because there is a critical period for language development, it is imperative that decisions about technology be made early in a child's life (Marcoux & Hansen, 2003). Although there are many forms of technology available for children with hearing loss, the two main types of sensory aids that will be discussed in this paper include hearing aids and cochlear implants.

Hearing aids

With the EDHI guidelines, children should be screened for hearing loss no later than 1 month of age, have a full evaluation by 3-months of age if they do not pass the screening, and receive proper intervention by 6-months of age after a confirmed hearing loss (JCIH, 2007). Carney and Moeller (1998) reported that the majority of children with hearing loss use hearing aids as their main avenue for receiving sensory information. After the family has made a decision about intervention options, it is the responsibility of the audiologist to properly select and fit hearing aids, if that is the direction the family chooses for their child. Although EDHI guidelines indicated proper intervention should occur before 6-months, amplification should be selected and fit within one month of a confirmed hearing loss, even if additional testing is necessary (JCIH, 2007). The earlier the process for selecting hearing aids and fitting occurs, the better chance the child will have of accessing language within the critical period.

According to the Joint Committee on Infant Hearing, the goal of the amplification fitting is to give the child the greatest amount of acoustical speech information as possible without exceeding a level that may damage the child's residual hearing and/or impart discomfort (JCIH, 2007). Marcoux and Hansen (2003) explained that if insufficient gain is provided to the child, they may miss certain elements of speech critical for the development of language, but if too much is applied to the fitting the child's hearing could be damaged. For children under the age of 6-months, hearing aid fittings must be based off electrophysiological testing, and verified using real-ear measures. Children over the developmental age of 6-months should have behavioral testing to confirm electrophysiological measurements before the time of the hearing aid fitting (JCIH, 2007). Although the short term goal of the hearing aid fitting is to provide the appropriate amount of gain, which in turn leads to increased access to auditory information, the long term goal of developing language and reading at age appropriate milestones needs to be explored.

Many studies have explored the language abilities and reading development of children with severe to profound hearing loss who use hearing aids. In most studies, researchers compare children who use hearing aids to children with a cochlear implant or implants. In the next section, some background information on cochlear implants will be provided and then a comparison between language and reading development in children with hearing aids versus children with cochlear implants.

Cochlear implantation

For a child who is not receiving enough benefit through traditional amplification, consideration of a cochlear implant or implants should be made after a dedicated trial period with hearing aids (JCIH, 2007). A cochlear implant is a device that bypasses the hair cells and directly stimulates the auditory nerve with electrical stimulation, instead of auditory stimulation. Although the information provided by the cochlear implant is very different than hearing through the normal auditory pathway, individuals are able to utilize the stimuli to develop speech and language (Spencer et al., 2003). The first cochlear implants that individuals were recipients of had only one electrode and provided only broad detection and timing cues, and did not prove to improve speech intelligibility in most patients (Carney & Moeller, 1998). When cochlear implants first became available in the 1980s, only individuals with bilateral profound hearing loss, older than 18-years of age were included in the candidacy pool. Cochlear implants were approved by the Food and Drug Administration in 1990 for children over 2-years of age with profound bilateral hearing loss. As of 2000, the candidacy criteria now includes children aged 12-months and older with bilateral profound hearing loss who fall within certain speech testing scores depending on the cochlear implant company (Tobey, 2010). With the improvements of the signal processing and internal and external hardware of the cochlear implant, combined with a broadening of candidacy criteria, the potential for children to benefit from cochlear implants has increased in recent years (Geers, Brenner, & Tobey, 2010; Lachs, Pisoni, & Kirk, 2001).

According to the National Institute on Deafness and Other Communication Disorders, 28,000 children in the United States have received a cochlear implant as of March 2011(NIDCD, 2011). Although many studies have shown improvements in speech perception and production in children who receive a cochlear implant, the research regarding improvements in reading development shows varied outcomes (Archbold, Harris, O'Donoghue, Nikolopoulos, White, & Richmond, 2008). With the advances in cochlear implant technology and the growing population of children receiving cochlear implants, important questions arise regarding language and reading development. Specifically, are children who receive cochlear implants developing language and reading development in the same time frame as children with normal hearing, and how do outcomes compare to children with hearing aids?

As mentioned earlier, the research concerning cochlear implants and reading development has had variable findings from study to study, and a conclusion has not been confirmed on this subject. Some studies have concluded that language and reading development in children with cochlear implants is not any better than in children with hearing aids (Most, Shina-August & Meilijson, 2010, Spencer & Tomblin, 2009, Schorr, Roth & Fox, 2008, Harris and Terlektsi, 2010). Other studies have shown improved reading development when children are implanted before 24-42 months of age (Nicholas and Geers, 2007, Archbold et al., 2008, Johnson & Goswami, 2010, Connor & Zwolan, 2004) and some studies have revealed that children who have cochlear implants are developing literacy at the same rate children with normal hearing (Yoshinaga-Itano, Baca & Sedey, 2010, Spencer et al., 2003, Dillon & Pisoni, 2006, Geers & Hayes, 2010, Lyxell et al,. 2009). Geers (2002) indicated that studies in the area of cochlear implants and literacy development have variable outcomes due to the following factors: cognitive skills of the child, motivation, educational and social environment, parental support, aural (re)habilitation, device fitting, unilateral or bilateral implantation, and type of communication mode.

As illustrated in previous chapters, language development is complex and involves many aspects. Literacy skills are usually developed following the acquisition of the 5 components of language. In a study by Most et al. (2010) 11 children with cochlear implants, 13 children with hearing aids, and 13 children with normal hearing were chronologically and linguistically matched and assessed on their pragmatic abilities. Using results from the pragmatic protocol, they found that the children with normal hearing had a significantly higher percentage of appropriate pragmatic behaviors than the children with hearing loss. They also found that the children with hearing aids had similar pragmatic abilities to the children with cochlear implants. They concluded that the children with hearing loss had not fully developed their pragmatic abilities to the level that the same age normal hearing child had demonstrated (Most et al., 2010).

In a study by Spencer and Tomblin (2009), 29 pre-lingual deaf children with cochlear implants were examined to determine their phonological awareness skills. Participants in the study had at least 3 years of experience with a cochlear implant, and were implanted before the age of 7 years. The control group consisted of 32 hearing children, and the subjects were matched based on word comprehension and mother's education level. The average age of the hearing control group was 2 years younger than the cochlear implant group; therefore results do not reflect the skills of an age group, but rather the relative abilities of the two groups. Various phonological tasks were completed including rhyming awareness and blending words task, among others. On the rhyming awareness task, the majority of the cochlear implant group scored over 86 percent, while some of the children with cochlear implants did not reach ceiling performance even by age 10 years. Typically children with normal hearing have achieved the maximum level of rhyming by the first grade. In the blending words task, the children with normal hearing reached ceiling performance by the age of 10, while some of the children with cochlear implants were still developing this skill into the teen years. The authors concluded that phonological awareness was a longer, more delayed process for the children with cochlear implants than the children with normal hearing.

Schorr et al. (2008), compared the language skills of a group of 39 children with cochlear implants and an age and gender matched group of 37 children with normal hearing. The study assessed various aspects of language development including:

semantics, syntax, and morphology. They found that the children in the cochlear implant group scored significantly lower on all measurements of semantics, syntax, and morphology. Only 36 percent of children in the cochlear implant group scored within age level norms on all three measures, compared to the normal hearing group which had 92 percent of children within age level norms. The study concluded that even in a group of high functioning cochlear implant users, significant language deficits exist when compared to children with normal hearing (Schorr et al., 2008).

Although the studies above have shown little improvement in language development from cochlear implants, there are studies that have more promising results. Yoshinaga-Itano et al. (2010) completed an observational longitudinal analysis of 87 children with severe to profound hearing loss, 38 with hearing aids, and 49 with cochlear implants. Outcome measures included the Test of Auditory Comprehension of Language, 3rd Edition (TACL-3), the Expressive One Word Picture Vocabulary Test, 3rd Edition (EOWPVT-3), and the Expressive Language subscale of the Minnesota Child Development Inventory. They found at 7 years of age, the children with cochlear implants scored significantly higher on the TACL-3 and the EOWPVT-3 tests than the children with hearing aids. They also found that in the cochlear implant group there were more “gap closers” than “gap openers”, meaning that there were more children with cochlear implants that were performing above the average age-equivalent instead of below the average age-equivalent. The opposite was true for the group of hearing aid users; there were more “gap openers” than “gap closers”. They came to the conclusion that the population of children as a whole who receive cochlear implants can reach expressive language and receptive syntax milestones on time.

Although most of the studies reviewed on language development in children with cochlear implants did not show much improvement over hearing aids, the studies to date on reading development are more optimistic. Spencer et al. (2003) performed a study with 16 children with cochlear implants, and 16 age-matched children with normal hearing. The goal of the study was to explore the link between language development and literacy skills in cochlear implant users. The average age of the subjects was 8 years, 9 months old. Using subtests from the Clinical Evaluation of Language Fundamentals-III (CELF-3) Passage Comprehension Test and from the Woodcock Reading Mastery Tests Revised Form (WRMT**)**, language skills and reading development levels were measured for each group. The results of the language subtests indicated a deficit in the expressive language task in the cochlear implant group. They also found that reading levels for the children with cochlear implants and the children with normal hearing were very similar. The mean grade equivalency of the cochlear implant group was 3.3, and the normal hearing group was 3.8 grade level equivalency. Based on this information, the authors concluded that the children with cochlear implants had reached the first critical stage of reading, and that the gap between hearing children and deaf children did not exist in this sample of children (Spencer et al., 2003).

Dillon and Pisoni (2006) conducted an analysis on data collected from a previous study by Geers (2003) to investigate phonological processing skills as they related to reading development in 76 children with cochlear implants. A nonword repetition task was used in order to measure phonological processing skills where subjects had to repeat nonwords after hearing a speaker present them. The results from the nonword task were compared to the results from 3 different reading and reading comprehension measures. They found that the cochlear implant users performed worse than would be expected for children their age on the nonword repetition task. A significant correlation was found between the score on the nonword repetition task and the total reading score. Because the nonword repetition task was a measure of phonological processing, the authors concluded that similarly to hearing children, phonological processing in children who are deaf relates to reading levels. Results also revealed that 70 percent of the subjects with cochlear implants had total reading standard scores within one standard deviation of the average score of the mean score of children the same age (Dillon & Pisoni, 2006).

Similar results were obtained in a study by Geers and Hayes (2010). Subjects included a group of 112 high school students with cochlear implants and a group of the same age high school students with normal hearing. Subjects were tested on vocabulary, comprehension, spelling, syntax, writing, and phonological processing. The aim of their study was to find out the reading levels of high school students who had received cochlear implants as preschoolers, as compared to normal hearing students. They also wanted to examine the correlation between early literacy skills and levels and literacy levels in high school. Results of the study indicated that between 47 percent and 66 percent of the high school students with cochlear implants scored at or above the mean score of their normal hearing peers on the Peabody Individual Achievement Test-Revised (PIAT-R). They also found that only 17 percent of the students with cochlear implants scored below a fourth grade reading level which was the previous average reading level of a high school graduate with severe to profound hearing loss. The individuals with cochlear implants tended to have poorer spelling and phonological processing skills than the normal hearing students. They came to the conclusion that children who are deaf with cochlear implants must use an alternate form of processing to transition from their poor phonological processing to better literacy skills in the high school years. Another conclusion of the study was that children who were better readers in elementary school were more inclined to be good readers in high school, but young poor readers could become better readers over time (Geers & Hayes, 2010).

Lyxell et al. (2009) found similar results in a group of 37 cochlear implant users from Sweden. Despite finding low abilities on phonological processing tasks in the children with cochlear implants, they found that 75 percent of the children were at a reading level comparable to the normal hearing children. They concluded that although children with normal hearing outperformed children with cochlear implants on cognitive and prosodic tasks, the disparity was reduced in tasks that did not involve specific phonological processing skills. The authors also concluded that children with cochlear implants could achieve similar reading levels to that of the same age children with normal hearing, despite the poor phonological skills (Lyxell et al., 2009). The deduction from most of the studies reported is similar; concluding that although language development may be lacking, especially phonological processing, children with cochlear implants can reach reading levels comparable to their peers with normal hearing.

There have been a number of studies that have shown that the earlier the child is implanted, the better the chance they have of developing age-appropriate language and reading skills. Nicholas and Geers (2007) reported that children implanted before the age of 2 years can achieve levels of spoken language comparable to their age-matched hearing peers before they enter kindergarten. They indicated that the older the child was at implantation, the more likely the child had of not catching up with their hearing peers in language development. Archbold et al. (2008) performed a study to explore the impact of an early implantation on reading development. Subjects included 105 children who were implanted between 16 and 83 months and were between the ages of 8 years, 4 months, and 13 years, 11 months. At 7 years post-implant, subjects completed the Edinburgh reading test, which includes subtests of vocabulary, sequencing, and sentence comprehension. A net reading age was calculated by using the difference between the child's chronological age and their reading age. Therefore, a net reading age of 0 or more would indicate the child was at or above the normative reading level of a child with normal hearing of the same age. The subjects were split into two groups, the children implanted before 42 months were the early group, and the children implanted after 42 months were the late group. The authors found a strong negative association between net reading score and age of implant, which indicates that the children implanted at an earlier age have a high net reading score. They also found that the children in the early group had reading levels close to their chronological age both at 5 years post implant, and 7 years post implant, whereas children in the late group was significantly below their chronological age. The results of this study suggest that there is a critical age for plasticity in the central auditory system in regards to literacy development (Archbold et al., 2008).

In another study by Johnson and Goswami (2010), a group of cochlear implants users was divided into an early cochlear implant group and a late cochlear implant group. Children implanted before 39 months were considered the early cochlear implant group, and children implanted after 43 months of age were in the late cochlear implant group. There was also a hearing aid group and a normal hearing group for control purposes. The authors were aiming to find out if the speech perception provided by the cochlear implants affected phonological awareness, and ultimately reading skills. They also wanted to investigate the impact of early implantation on children's reading development. Results indicated that children in the early cochlear implant group attained reading scores close to their normal hearing peers, and that were significantly greater than the later cochlear implant groups' reading scores (Johnson & Goswami, 2010). Connor and Zwolan (2004) also found that a younger age of implantation was associated with a higher reading comprehension score. This study was conducted before the FDA regulations decreased the age of implantation from 2 years to 12 months, so it is expected that current children would be receiving implants even younger than the children in their study sample.

Despite the prior studies with positive outcomes regarding cochlear implants and reading development, there have been occasional studies with the opposite results. Harris and Terlektsi (2010) compared the reading levels of a group of early implanted cochlear implant users, a group of later implanted users, and a group of hearing aid users all between the ages of 12 and 16 years. All subjects had unaided thresholds of 85 dB HL and greater, and were age and IQ matched. They found that the hearing aid users were most likely to be reading within 12 months of their chronological age over the children with cochlear implants. Although Harris and Terleksi found better reading skills in the hearing aid group, there was one very important characteristic of this particular sample that could account for the results obtained. A majority of the children with hearing aids were in a school for the deaf, and the majority of the children with cochlear implants were in a mainstream setting or a specialized unit attached to a mainstream school. They indicated that the children with hearing aids at the school for the deaf would be receiving specialized support regarding language and reading development. They also implied that most of the children with cochlear implants in the mainstream schools were on target with their reading development, but the children in the specialized unit were the students that were behind in their reading development. These findings may indicate that children needing a specialized unit would benefit from the increased support in a school for the deaf (Harris & Terleksi, 2010).

After a review of the current research in the area of technological intervention and language and literacy development, a few conclusions can be made. First, children with severe to profound hearing loss with hearing aids or cochlear implants are still behind their age-matched peers in most aspects of language development. Despite this fact, children with cochlear implants are beginning to bridge the reading deficit gap between children who are deaf and children with normal hearing. Numerous studies have documented children with cochlear implants are scoring at or close to their chronological age in reading tasks. Many studies have also shown the benefits of early implantation on reading development, and the research will most likely continue to show promising results as more children are getting implanted as young as 12-months old. It is very important to mention that the device itself (cochlear implant or hearing aid) is only a part of the process to bridging the literacy gap. Appropriate (re)habilitation, programming strategy and mapping by the audiologist, educational setting, parent participation, and emphasis on auditory skill development are all factors that contribute to the success of the child with a cochlear implant(s) (Geers, 2002).

CHAPTER FIVE

Conclusion

A developmental lag in language and literacy skills in children with severe to profound hearing loss is a well researched and documented issue. Fortunately, with the advent of the Universal Newborn Hearing Screening program, children who are deaf are identified earlier, and are able to receive early intervention while they are still in their critical age for language development (Marcoux & Hansen, 2003). Improvements in amplification technology (e.g., hearing aids and cochlear implants) have increased children's opportunity for increased auditory information, with the hope of improved language development, which leads to the development of literacy. After reviewing the current literature on the topic, the conclusion that the large literacy gap that previously existed between children with normal hearing and children who are deaf is slowing closing. Many studies have acknowledged that early implantation of cochlear implants gives a child who is deaf the greatest chance to succeed in reading, however much more research needs to be completed in this area. With the age of cochlear implantation decreasing, research needs to continue to gather evidence that early implantation is best for a child with severe to profound hearing loss. One issue without much documented research is the outcomes of children that receive bilateral implants as compared to a unilateral implant, or a child who is bimodal. As technology improves, methods for teaching children who are deaf are enhanced, improvements in aural (re)habilitation are made, and the age of intervention decreases, the literacy gap should continue to close for children with severe to profound hearing loss.

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